National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, MD 20771

November 2, 2001

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DOCUMENT #: 474-CORR-0020

SUBJECT: NCS Performance During Structural Coupling Test (GUS event #148)

Test Description

The GUS integrated test that occurred on October 25th of 2001 (event #148) included a fully configured Nutation Control System (NCS). Both strings (A and B) were installed on the GUS using pseudo-flight NCS Electronic Units (NEUs S/N 02 and 03), and both Reaction Control Assemblies (RCAs S/N 001 and 002) were loaded with GN_2 pressurent to flight levels (3500 psi at 25°C). During the test, the isolation valves on the RCAs were by-passed such that the GN_2 could flow through the system and vent into the building 11 acoustic chamber. The test was performed per 474-PROC-175.

The Hybrid Dynamic Simulator (HDS) was connected to the NCS ground test connectors and used to inject a simulated Quartz Rate Sensor (QRS) signal during the test time-line in order to stimulate the NCS and, more specifically, to induce RCA thruster firings. The configuration parameters for the (internal) HDS model that were used in conjunction with event #148 are included at the end of this report. The QRS sensor enable/disable switches on the HDS electronics panel were *enabled* for this test; therefor the simulated rate signal generated in the dynamics model was added to the output of the QRS for each of the NEU.

Additionally, tri-axial accelerometers were placed at four locations on the GUS. Two were allocated for each string and were located on the GUS deck in the vicinities of the NEUs and RCA nozzles respectively. The NEU valve command pulses were also monitored at the HDS data ports to be used as markers in the accelerometer data. The test data was sampled at 1KHz by an independent acquisition apparatus. Data from the accelerometers is archived in the Triana configuration management system along with this report.

Using the sensor compliment described above, this test configuration was intended to determine the extent of the structural coupling of the RCA thruster firings onto the QRS signal. The results have been analyzed for potential NCS performance impact.

Test Results

Immediately after the start of the test, during the Coast phase “tip-off” recovery period, it was clear that the NCS thruster pulses were having a profound affect on the rate sensor signals. As a result, several unanticipated events occurred in the control sequence:

A) *NCS string A was disabled by the firmware approximately 30 seconds after simulated ejection.*

B) *NCS string B failed to reduce nutation to the expected level during a particular pulse-pair occurring approximately 12-minutes after simulated ejection.*

C) *The frequency of thruster firings during the end-of-burn instability (RGAIN) was more rapid than expected.*

Figure 1 shows the rate signal recorded by the HDS. It is the sum of the injected HDS rate and the QRS' response to physical excitation measured at the output of the NEU bandpass filter. (The blue circles on the plot indicate the start of each new HDS data collection buffer.) Each time the thruster was activated, higher frequency dynamics were detected on the rate signal. The analysis that follows will focus on the three periods in which the NCS performance was significantly off- nominal.

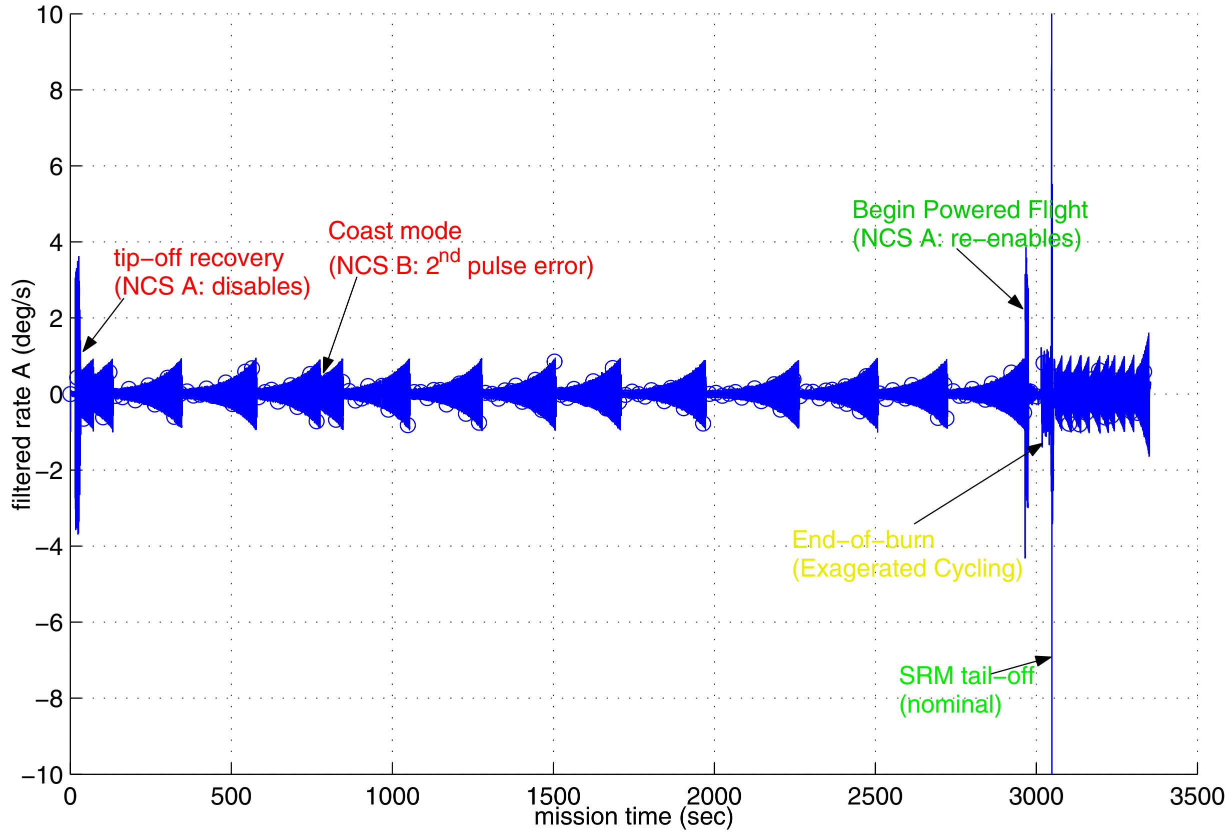
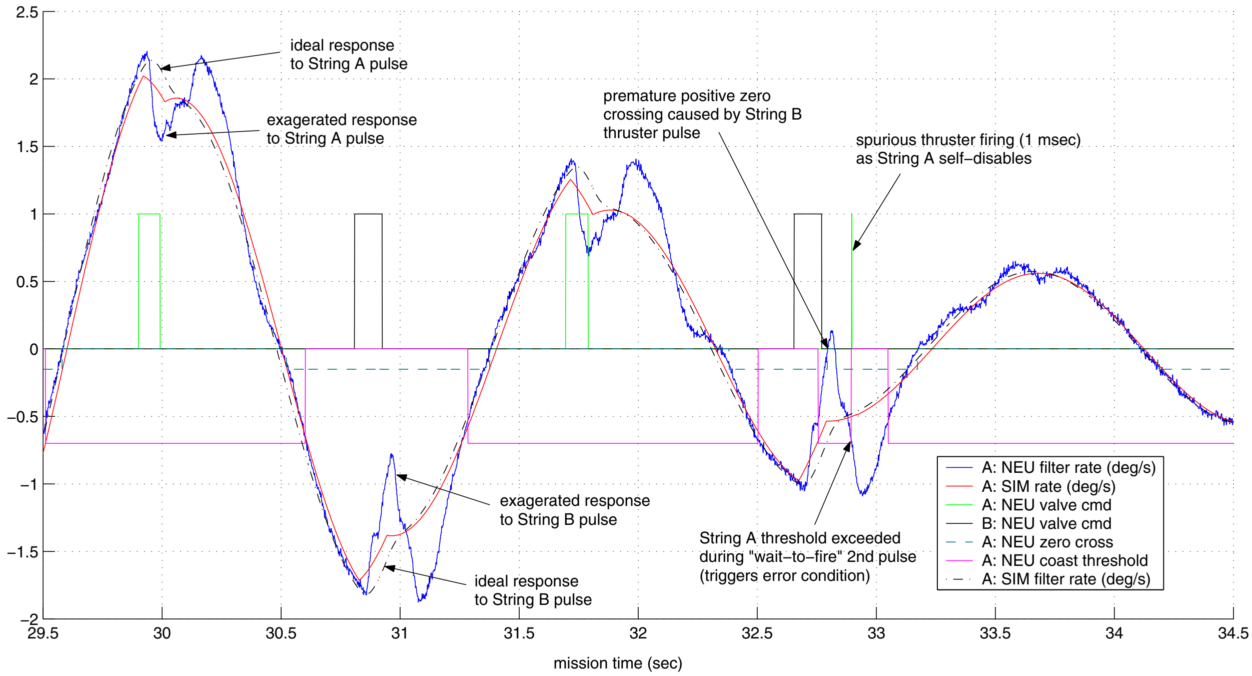


Figure 1 : *NCS String A Filtered Rate (GUS Event 148)*

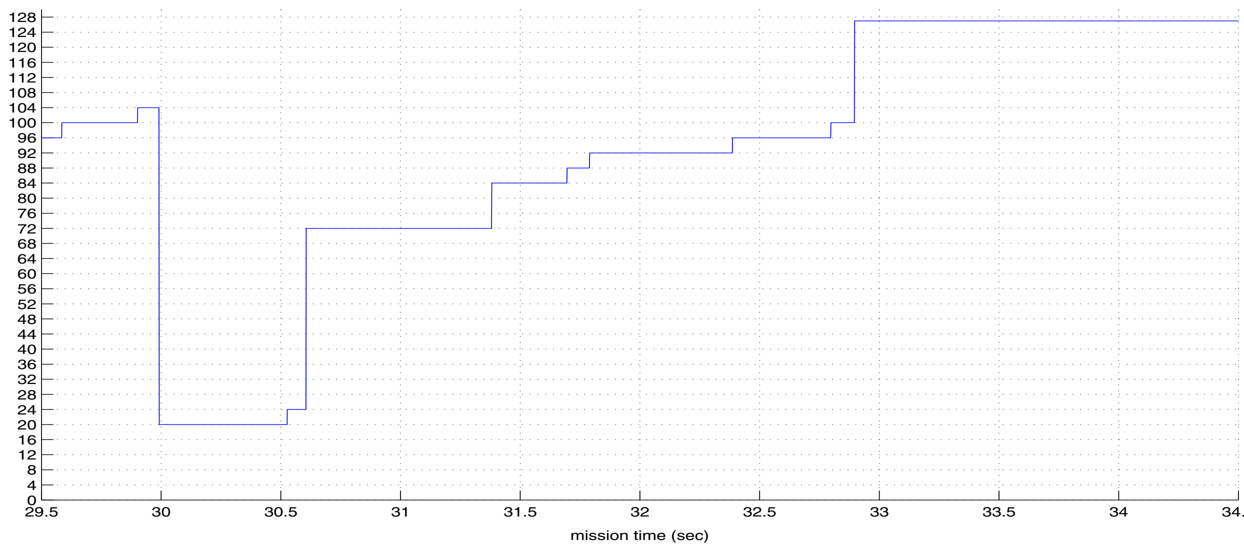
Event A: NCS String A Auto Disables

Figure 2 is an expanded view of Figure 1 at the time when string A disables. The string A firmware switched to state 127 (0x7F) which only occurs when an error condition associated with the Coast threshold comparator signal is detected. Once this state is entered, NCS activity is suspended for the remainder of Coast mode. (Active control did resume as expected in string A after the GUS entered into Powered Flight mode.)

A careful examination of the signals in Figure 2(a) shows the sequence of events that resulted in the error condition. The root cause of the anomalous behavior for the entire mission simulation is the coupled response of the QRS to the thruster firings. While some coupling was expected in a test whose primary purpose was to characterize the magnitude of the interaction, the actual response was an order of magnitude higher than anticipated (greater than 1.0 deg/sec in some cases). Additionally, as indicated by the V-shaped notches in the peaks of the filtered rate sinusoid, the characteristics of the disturbance do not



(a) Selected NEU signals



(b) Firmware State (Port 4)

Figure 2 : *Event A NEU Signals*

conform to the oscillatory motion expected for structural flexure. Also shown in Figure 2(a) is the simulated unfiltered rate signal (red) that indicates the expected (HDS model) response of the spinning *rigid-body* spacecraft to the thruster moments in an orbital environment.

Once the amplitude of the filtered rate signal was less than the magnitude of the RCA induced rate disturbance, activation of the string B thruster during the negative half of the nutation cycle caused a premature (positive) zero-crossing in the string A rate signals. As a result, the zero-crossing detector input into the NEU controller toggled, and the firmware entered state 104 (0x68), which is a count-down to fire the second pulse of the matched pair. After the string B thruster valve closed and the string A rate signal started its return to the undisturbed (simulator tracking) trajectory, the overshoot was of sufficient amplitude to trigger the string A threshold comparator. Receiving a “threshold exceed” signal during a period in which the NCS is firing or preparing to fire will trigger an error condition in the firmware that disables operation of the string for the remainder of the Coast phase and places the controller in state 127 (0x7F), where it will remain until the switch to Powered Flight mode occurs. Unexpectedly, a spurious valve open command was also issued by the NEU during the sample interval (1-millisecond) in which the error condition was initially detected. Further investigation determined that an error does exist in the firmware (v2.5). This error momentarily toggles the valve command *on* before disabling the string. While the potential impact on flight performance of such a short duration pulse is negligible, nevertheless this is a genuine coding error that should be corrected.

In summary, examination of the logged data surrounding the event A shut-down shows that the controller performed in a manner consistent with the design intent. Furthermore, the disabling of string A, although undesirable from a mission performance stand point (but not in-and-of-itself fatal), can be attributed to an input signal outside of expected operating parameters.

Event B: NCS String B Phasing Error

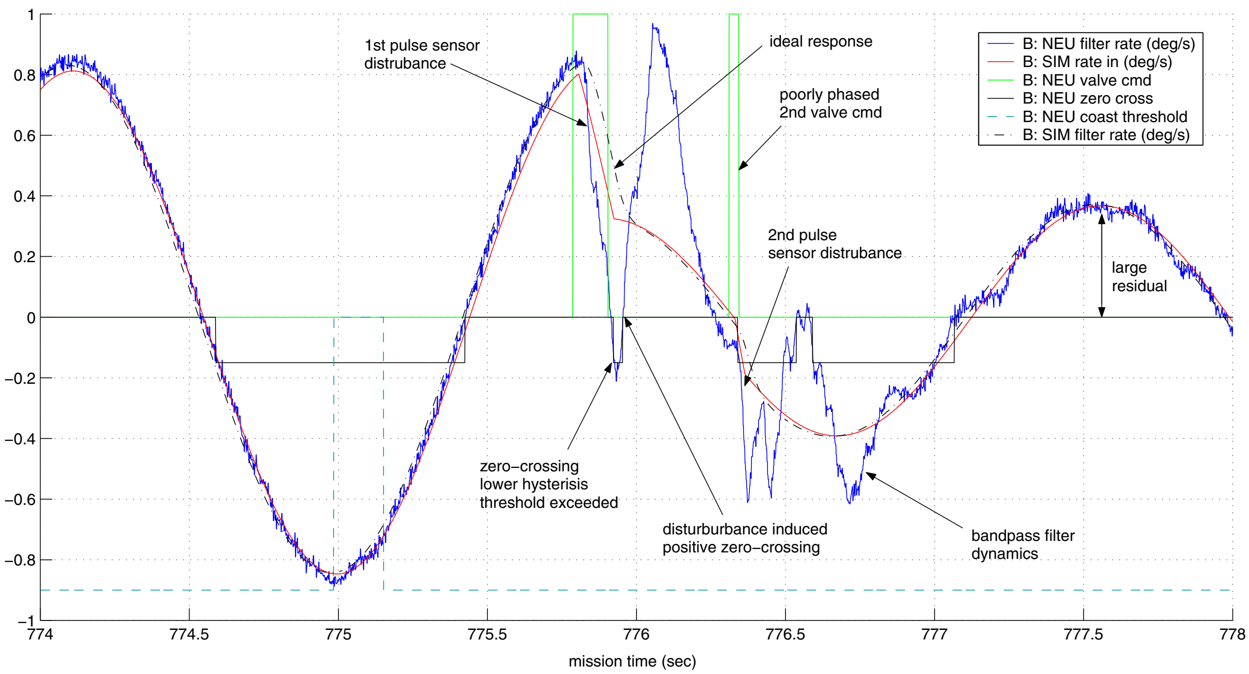
The Event B anomaly occurred approximately 14-minutes into the mission simulation. At that time, the NCS was operating solely on string B since string A had already auto-disabled. It was immediately clear after the second command of the pulse-pair, that the residual transverse rate of the simulated spacecraft was significantly higher than anticipated. This type of result is indicative of a phasing/timing error. A detailed view of the relevant system signals is shown in Figure 3.

As seen with the Event A anomaly, there were large disturbances on the filtered rate signal associated with the RCA thruster firings. Furthermore, in the case of the first pulse, the disturbance caused the filtered rate signal to momentarily dip below the lower threshold of the zero-crossing detector (-0.15 deg/s) before returning to a positive value. Due to the RCA valve delay (~20 msec) and the bandpass filter phase lag (which is approximately 4-degrees or an additional 20-msec for the 0.56 Hz nutation rate being simulated), this sequence of events occurred after the first pulse had terminated. This allowed the firmware to prime itself for the second pulse of the pair. Note that had the zero-crossing (low) occurred *during* the first pulse, the second pulse would have been aborted. As it was, the disturbance induced zero-crossing perturbed the phasing of second pulse so that it occurred when the simulated transverse body rate was effectively orthogonal to the moment induced by the RCA. In accordance with the simulated spacecraft gyro dynamics, the second pulse had minimal nutation reducing effect and hence the large residual rate. Additionally, the valve open command was abbreviated by the firmware when the zero-crossing detector switched low (at the lower hysteresis level).

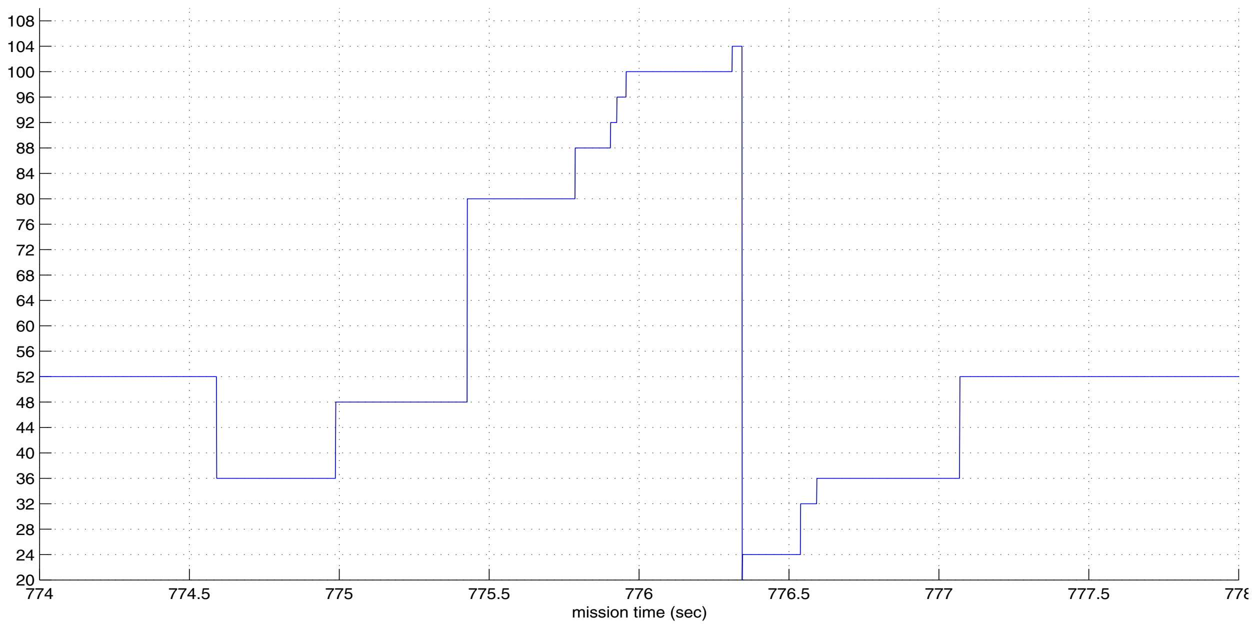
As was the case with Event A, there is no indication of a system malfunction associated with the Event B anomaly. All anomalous behavior can be attributed to the large amplitude rate signal disturbances associated with RCA thruster firings.

Event C: NCS Strings A and B Powered Flight Activity

Figure 4 shows NCS string A activity immediately after the application of the end-of-burn coning instability (RGAIN) moment. The anomalous feature for this period is the frequency of the pulses that occurred. A more typical result would show at most two valve actuations



(a) Selected NEU signals

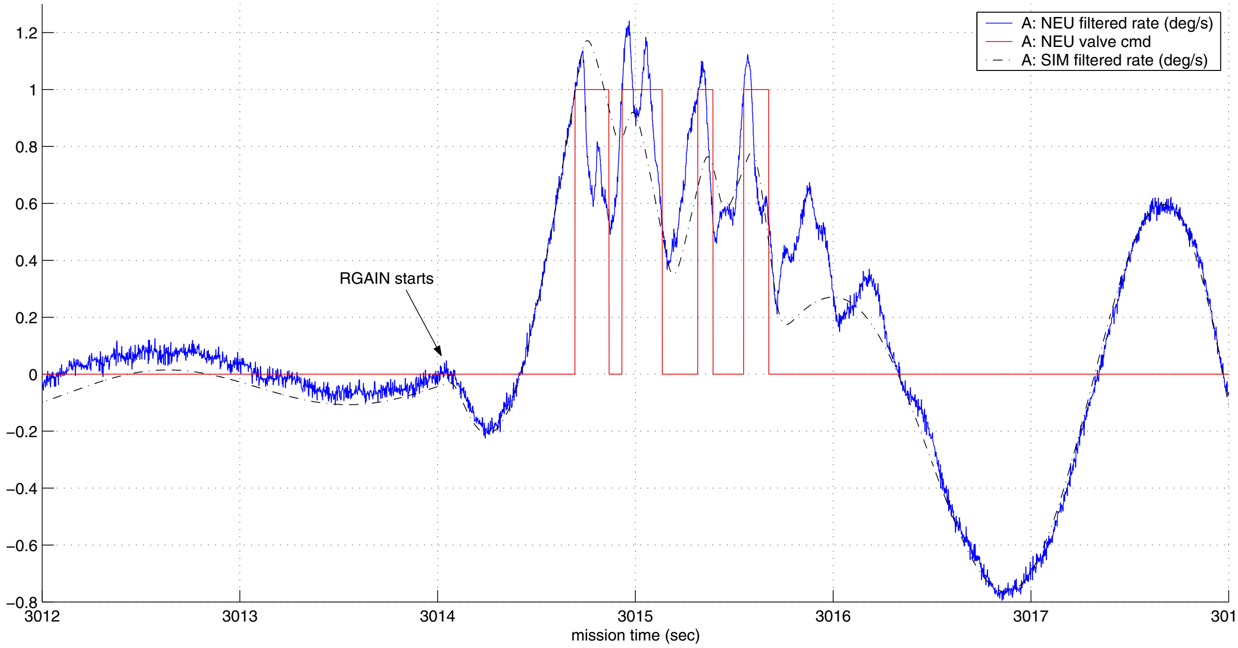


(b) Firmware State (Port 4)

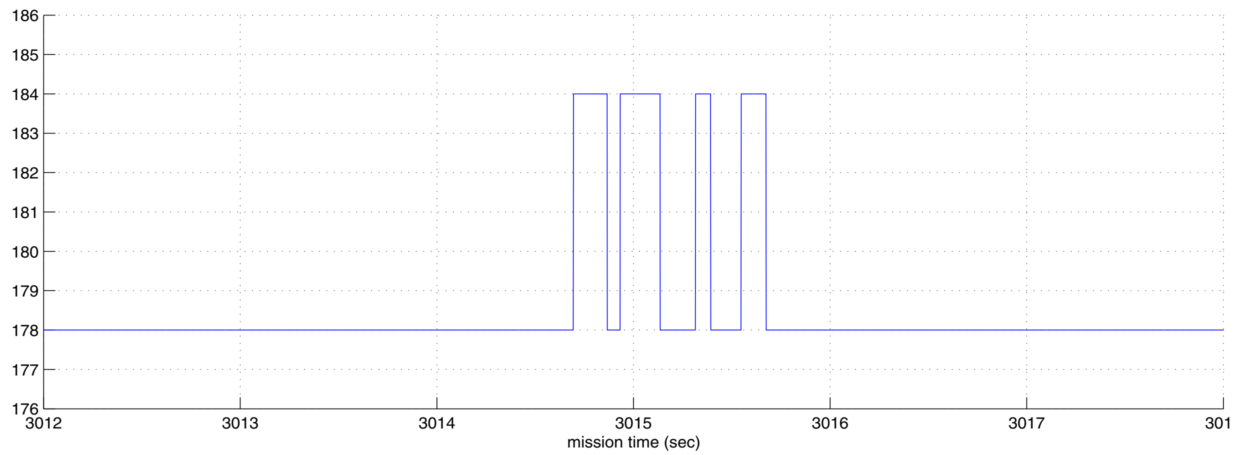
Figure 3 : *Event B NEU Signals*

during an identical time span. Behavior of this sort would have minor impact on flight performance, leading only to some increased fuel consumption.

Clearly the system response associated with this event is just another manifestation of the signal distortion caused by RCA thruster firings. The exaggerated response of the filtered rate signal repeatedly causes the Powered Flight lower threshold to trip prematurely and the valve to close. As the system overshoots its recovery from the sudden removal of the disturbance, the Powered Flight upper threshold is also exceeded. This process repeats until the injected rate signal amplitude falls below both thresholds. There is no indication of aberrant activity in the controller itself.



(a) Selected NEU signals



(b) Firmware State (Port 4)

Figure 4 : *Event C NEU Signals*

Hypothesis

The cause of the of the large amplitude disturbances to the filtered rate signals is suspected to be rigid-body motion of the GUS in response to the RCA thrust (as detected up by the "live" QRS), which is not the type of structural coupling the test was intended to characterize. During thruster firings the GUS structure, which was mounted (*sans* SRM and Observatory) on a wheeled dolly with compliant suspension, was observed to visibly displace. Provided this explanation is valid, the "V" shaped notches noted in Figures 2(a), 3(a) and 4(a) may be explained as angular rotations first in one direction when thrust is applied, and then followed by a "rock-back" after thrust is terminated. The latter response would be a function of the dolly's suspension stiffness and weight of the GUS.

Also note that the six independent tri-axial accelerometer data recorded during GUS run 148 also shows significant structural response during periods of RCA activity. This effectively eliminates the NEU/GSE (or interface) as a source for the rate signal anomalies, and supports the credibility of a physical phenomena explanation.

Additional Testing

In order to determine if the GUS mounting was truly the cause of the large rate disturbances, several additional tests were performed. First, the QRS input was disabled *via* the HDS GSE, so that the stimulus to the NEU was solely the simulated rate signal. As expected, the disturbance to the filtered rate signal was absent during thruster firings. Next, the QRS signal summing was re-enabled and an attempt was made to reduce rigid-body motion by replacing the wheeled suspension system with rigid jacks. As shown in Figure 5(a), the magnitude of the RCA induced disturbances is nearly absent in the inter-string coupled response (i.e. string A rate when string B is firing and *visa versa*), and persists with a significantly altered characteristics for the intra-string response. In the case of the latter effect, the rate signal characteristics are in better accordance with a flexible body response, and also indicates the GUS deck may have a primary flexible mode at approximately 24 Hz.

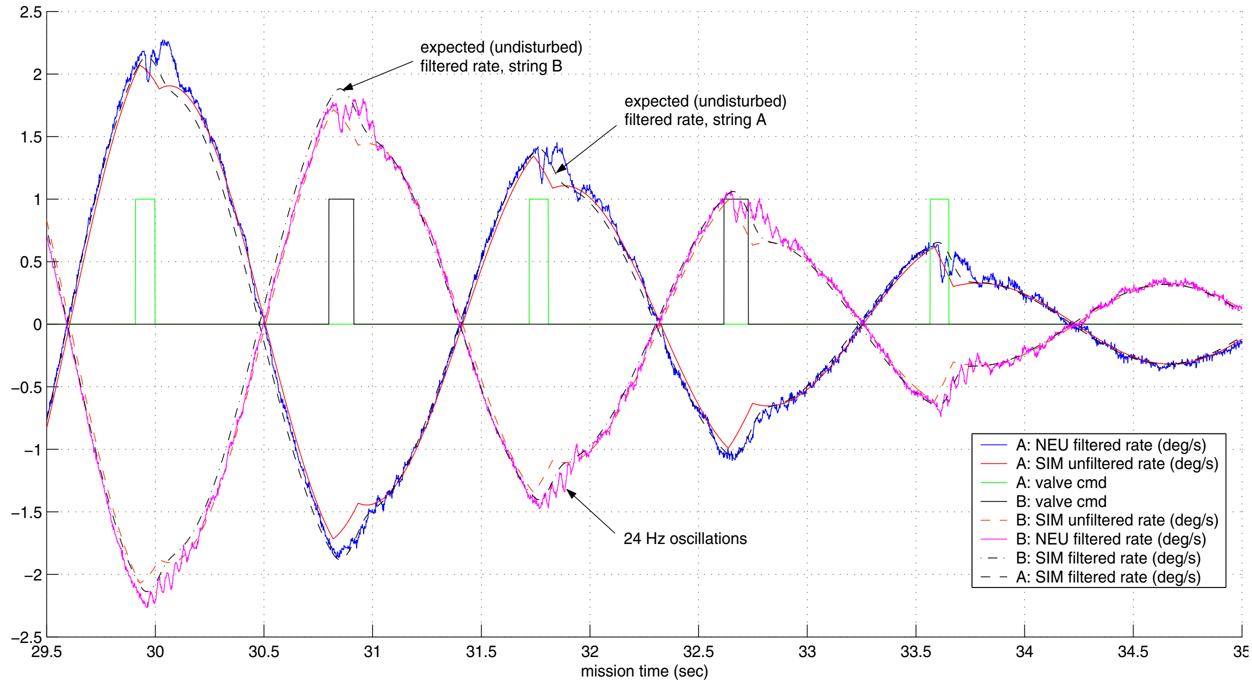
It should also be mentioned that a significant leak across the RCA-A regulator was detected following run #148 (ref. NCR ID: TRIANA2001103001). This failure implies that string A was operating at higher thrust levels for at least a portion of the initial and follow-up runs. Also, both system were not recharged to full flight levels for the diagnostic testing. At the end of run #148, tanks A and B contained only slightly more than 2633 and 1982 psi respectively. Nevertheless, when the support jacks were removed and the wheeled dolly again used to support the GUS, an additional test (GUS run #151r4) with even lower starting pressures (3094 and 1735 psia) showed approximately 60% restoration of the large magnitude disturbances to the filtered rate signal. Figure 5(b) shows some of the details of this last test.

Summary

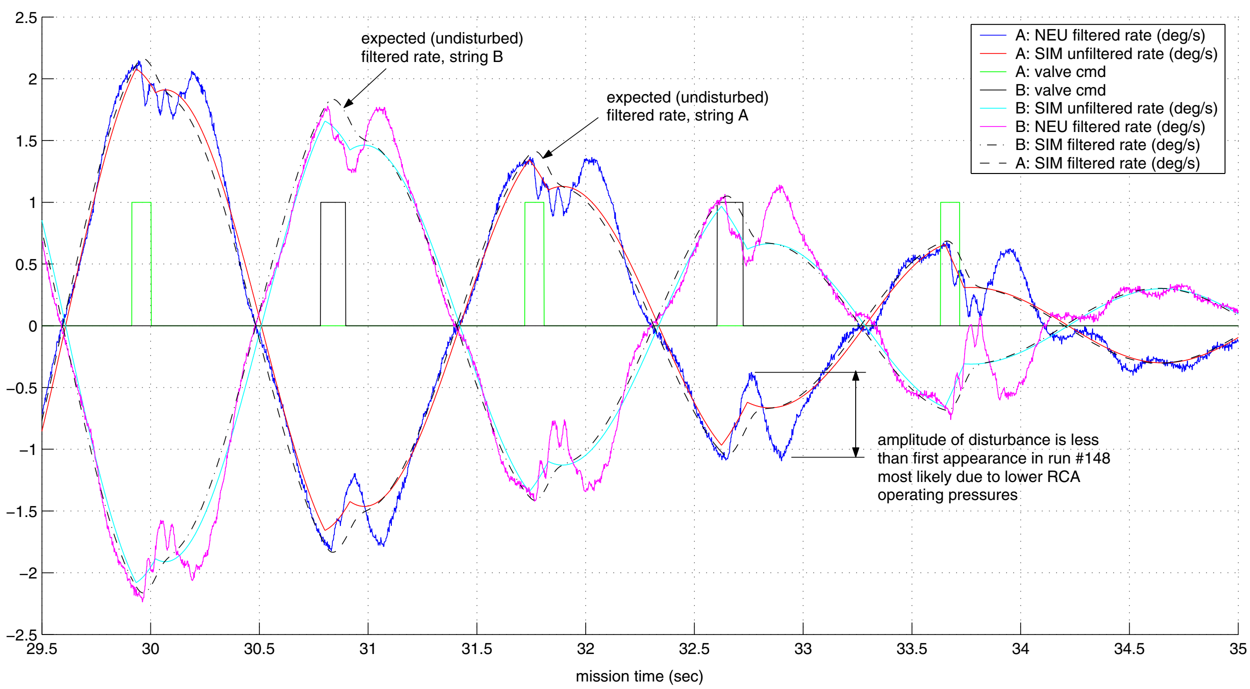
The suspected cause of the anomalies associated with GUS run #148 are believed to be rigid body rotations of the GUS structure in response to the RCA activity. Additional tests conducted immediately after the initial events seem to corroborate this belief. A careful examination of system telemetry surrounding the anomalous events has shown, with only one exception, that the NCS controller performed in accordance with the design intent. The sole exception is a spurious valve open command inserted by the firmware for one control cycle (one millisecond) as it switches into a stable error-handling state.

The open issue of structural coupling into the QRS due to thruster firings remains a concern. As plainly demonstrated by the system's behavior during run #148, large amplitude disturbances can have a significant effect of the NCS performance during the mission. It is therefore recommended that further testing be performed with the GUS rigidly constrained, so as to better isolate the flexible-structure response, since the rigid body dynamics are already well understood and believed to be adequately modeled.

Lastly, an additional benefit may be gleaned from the test data. Supposing that the QRS signal disturbance does represent rigid body rotational rates, it would appear that the spacecraft's motion would have been in a direction that <u>reduces</u> the instantaneous amplitude of the transverse body rate. Had the simulated unfiltered rate signal originated from actual gyro dynamics, this effect would be stabilizing and reduce the nutation of the spacecraft. This observation implies the phasing of the rate sensor in relation to the thrusters is correct and, in a rough sense, the system is aligned correctly.



(a) using jack supports (GUS run #151r3)



(b) using wheeled supports (GUS run #151r4)

Figure 5 : *Follow-up Testing NEU Signals*

CONFIGURATION: gus148.cfg Page 1/3

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TRIANA GYROSCOPIC UPPER STAGE DYNAMIC SIMULATOR
-----------------------------------------------

SIMULATION PARAMETERS
---------------------
SIM.endtime     =       5155.000
SIM.stepsize    =          0.001
SIM.syncstart   =         15.000

DATA LOGGING
------------
SIM.rundate             =       ??/??/??
SIM.Archive.enable      =       1
SIM.Archive.Dir         =       .\LOGdata\gus148
SIM.Archive.File        =       TDSlog
SIM.Archive.Config      =       gus148
SIM.Archive.autonaming  =       1
SIM.Archive.buffer      =       20000

COORDINATE TRANSFORMATIONS
--------------------------
dcm_srm2sas             =       −0.38268343      0.92387953      0.00000000
                                −0.92387953     −0.38268343      0.00000000
                                 0.00000000      0.00000000      1.00000000
r_sas2dads_sc           =        0.00000000      0.00000000      69.32700000

GEOMETRY
--------
SRM.geo.nozzle.midpt    =        0.00000000      0.00000000     −0.57876440
SRM.geo.nozzle.exit     =        0.00000000      0.00000000     −0.92603320

MASS PROPERTIES
---------------
SC.Eject.Mass           =       2986.000
SC.Eject.Inertia        =        1760.59130000   4.09700000      0.00000000
                                 4.09700000      1753.94700000   0.00000000
                                 0.00000000      0.00000000      613.57380000
SC.Eject.PrinAx         =        1762.54381488   1751.99448512   613.57380000
SC.Eject.CM             =        0.00000000      0.00000000      0.54731920
dcm_b2p                 =        0.90272684     −0.43021420      0.00000000
                                 0.43021420      0.90272684      0.00000000
                                 0.00000000      0.00000000      1.00000000
SC.Fixed.Mass           =       836.013443
SC.Fixed.CM             =       −0.00878336     −0.00049889      1.42017315
SC.Fixed.Inertia        =        464.62207138    4.17931914     −4.65373139
                                 4.17931914      456.39209762   −0.26432949
                                −4.65373139     −0.26432949      244.70227310

SOLID ROCKET MOTOR
-----------------
SRM.Ballistics.file             =       SRMballistics.dat
SRM.Lateral.enable              =       1
SRM.Lateral.file                =       SRMlateral.dat
SRM.IgnitionImp.enable          =       1
SRM.IgnitionImp.magnitude       =       13.344665
SRM.IgnitionImp.angle           =         1.5708
SRM.Jdamp.enable                =       1
SRM.Jdamp.multiplier            =         1.0000
SRM.MProps.file                 =       SRMmprops.dat
SRMMPropsIdot                   =       −0.00000021      0.00002567
                                        −0.00157530      0.05545381
                                        −4.72088971      0.00000129
                                        −0.00018486      0.00861401
                                        −0.22183801     −0.41122328
SRM.IgnitionImp.magnitude       =       13.344665
SRM.RGAIN.enable                =       1
SRM.RGAIN.K1                    =       6.991438e+02
SRM.RGAIN.K2                    =       6.991438e+02
SRM.RGAIN.starttime             =       50

RCA
---
GN2.A.InitMass          =       6.799350
GN2.B.InitMass          =       6.799350
GN2.A.CM                =        0.51666140      0.44127420      0.78640940
GN2.B.CM                =        0.56329580     −0.37993320      0.78640940
dcm_tankA2sas           =       −0.64944805      0.76040597      0.00000000
                                −0.76040597     −0.64944805      0.00000000
                                 0.00000000      0.00000000      1.00000000
dcm_tankB2sas           =       −0.55919290     −0.82903757      0.00000000
                                 0.82903757     −0.55919290      0.00000000
                                 0.00000000      0.00000000      1.00000000
GN2.A.KInertia          =        0.02806204      0.01742390      0.00000000
                                 0.01742390      0.02254269      0.00000000
                                 0.00000000      0.00000000      0.04294346
GN2.B.KInertia          =        0.03191084     −0.01635654      0.00000000
                                −0.01635654      0.01869390      0.00000000
                                 0.00000000      0.00000000      0.04294346
RCA.A.tank.gam          =       1.710000
RCA.B.tank.gam          =       1.710000
RCA.A.tank.temp0        =       294.261111
RCA.B.tank.temp0        =       294.261111
RCA.A.tank.vol          =       0.026727
RCA.B.tank.vol          =       0.026727
RCA.A.tank.density0     =       254.397162
RCA.B.tank.density0     =       254.397162
RCA.A.reg.af            =       0.000000
RCA.B.reg.af            =       0.000000
RCA.A.reg.cf            =       163.350000
RCA.B.reg.cf            =       163.350000
RCA.A.reg.ap            =       0.000000
RCA.B.reg.ap            =       0.000000
RCA.A.reg.cp            =       7396700.000000
RCA.B.reg.cp            =       7396700.000000
RCA.A.throat.gam        =       1.5000
RCA.B.throat.gam        =       1.5000
RCA.A.throat.area       =       0.000014
RCA.B.throat.area       =       0.000014
RCA.A.throat.K_mdot     =       −0.0000005753
RCA.B.throat.K_mdot     =       −0.0000005753
RCA.A.nozzle.position_b =       −0.09159240      0.82946240      0.58102500
RCA.B.nozzle.position_b =        0.09159240     −0.82946240      0.58102500
RCA.A.nozzle.ClockAngle =       6.300000
RCA.B.nozzle.ClockAngle =       6.300000
RCA.A.nozzle.CantAngle  =       10.000000
RCA.B.nozzle.CantAngle  =       −10.000000
RCA.A.nozzle.uvec_b     =        0.01905516     −0.17259951      0.98480775
RCA.B.nozzle.uvec_b     =       −0.01905516      0.17259951      0.98480775
RCA.A.efficiency        =       1.0000
RCA.B.efficiency        =       1.0000
RCA.A.Isovalve.OpenTime =       12.0000
RCA.B.Isovalve.OpenTime =       12.0000
RCA.A.Cntrlvalve.delay  =       0.0200
RCA.B.Cntrlvalve.delay  =       0.0200
```

CONFIGURATION: gus148.cfg Page 2/3

```
HYDRAZINE SLOSH
---------------
Fuel.MaxEdot.enable     =       1
Fuel.SteadyState.enable =       1
Fuel.TankRadius         =       0.355600
Fuel.Mass               =       145.000000
Fuel.Inertia            =        7.33417888      0.00000000      0.00000000
                                 0.00000000      7.33417888      0.00000000
                                 0.00000000      0.00000000      7.33417888



INITIAL CONDITIONS
------------------
SC.Eject.STS_vel_i      =        2266.4180       5838.9390       4538.4010
SC.Eject.position_i     =        6356341.3820   −1289011.8640   −1515186.0850
SC.Eject.angrate_b      =        0.05235988      0.00000000      5.44542727
SC.K1                   =       8.000
Fuel.Eject.angrate_rel_b =       0.04874182      0.04968525     −0.00135864
SC.Eject.TTI            =       −0.11439412     −0.77752169     −0.61836397
q_i2tti =        0.637105519234 −0.635042159530  0.260063828557  0.350976948042
SC.Eject.h0_b           =        92.54182613     0.57891895      3341.16153588
SC.Eject.q_i2b=  0.640674620015 −0.639818722945  0.251273756037  0.342095794427
SC.Eject.rel_vel_b      =        0.00000000      0.00000000      0.49750000
SC.Eject.velocity_i     =        2266.37690716   5838.55430450   4538.08822692
Fuel.Eject.angrate_i    =       −0.67408019     −4.19973974     −3.39976108

EVENT SEQUENCING
---------------
SRM.IgnitionTime                =       2820.000000
SRM.IgnDelay                    =       5.000000
EVSEQ.Eject.Jday                =       2451971.460370
TESS.A.PwrFlt.cmd.source        =       2.000000
TESS.A.PwrFlt.cmd.delay         =       −5.000000
TESS.A.PwrFlt.cmd.time          =       2815.000000
TESS.A.PwrFlt.cmdfail.enable    =       0.000000
TESS.A.PwrFlt.cmdfail.delay     =       9999.000000
TESS.A.PwrFlt.cmdfail.time      =       12814.000000
TESS.A.Inactive.cmd.source      =       1.000000
TESS.A.Inactive.cmd.delay       =       322.000000
TESS.A.Inactive.cmd.delay       =       322.000000
TESS.A.Inactive.cmd.time        =       3142.000000
TESS.A.Inactive.cmdfail.enable  =       0.000000
TESS.B.PwrFlt.cmd.source        =       2.000000
TESS.B.PwrFlt.cmd.delay         =       −5.000000
TESS.B.PwrFlt.cmd.time          =       2815.000000
TESS.B.PwrFlt.cmdfail.enable    =       0.000000
TESS.B.PwrFlt.cmdfail.delay     =       9999.000000
TESS.B.PwrFlt.cmdfail.time      =       12814.000000
TESS.B.Inactive.cmd.source      =       1.000000
TESS.B.Inactive.cmd.delay       =       322.000000
TESS.B.Inactive.cmd.time        =       3142.000000
TESS.B.Inactive.cmdfail.enable  =       0.000000
TESS.B.Inactive.cmdfail.delay   =       9999.000000
TESS.B.Inactive.cmdfail.time    =       13141.000000

GRAVITY
---------------
GRAV.enable             =       1
GRAV.mu                 =       3.986012e+14
GRAV.SHarmonic.enable   =       0
GRAV.SHarmonic.J2       =       1.082640e−03
GRAV.Re                 =       6378145.000

AERODYNAMICS
---------------
AERO.enable             =       1
AERO.Cd                 =           3.00
AERO.Rcyl               =       0.869950
AERO.Hcyl               =       3.840912
AERO.CP                 =        0.43497500      0.00000000      1.95447920

ATMOSPHERE
---------------
ATM.f                   =       0.003353
ATM.F107                =       250.000000
ATM.F107A               =       250.000000
ATM.Kp                  =       4.000000
ATM.KpA                 =       4.000000


QRS
---
QRS.rps2V                       =       7.161972
QRS.A.Noise.enable              =       0
QRS.B.Noise.enable              =       0
  QRS.A.Noise.PSD               =       0.00000001
  QRS.B.Noise.PSD               =       0.00000001
  QRS.A.Noise.SampleTime        =       0.0010
  QRS.B.Noise.SampleTime        =       0.0010
  QRS.A.Noise.Seed              =           81735753
  QRS.B.Noise.Seed              =           42564811
  QRS.A.Drift.PSD               =       0.00000000
  QRS.B.Drift.PSD               =       0.00000000
  QRS.A.Drift.SampleTime        =       0.0010
  QRS.B.Drift.SampleTime        =       0.0010
  QRS.A.Drift.Seed              =          617679313
  QRS.B.Drift.Seed              =          931316785
  QRS.A.Drift.TurnOn            =       0.008727
  QRS.B.Drift.TurnOn            =       0.008727
QRS.A.Gsense.enable             =       0
QRS.B.Gsense.enable             =       0
  QRS.Gsense.x                  =       0.000004
  QRS.Gsense.y                  =       0.000004
  QRS.Gsense.z                  =       0.000036
QRS.A.ScaleError.enable         =       1
QRS.B.ScaleError.enable         =       1
  QRS.A.ScaleError.temp         =       0.000000
  QRS.B.ScaleError.temp         =       0.000000
  QRS.A.ScaleError.cal          =       0.005000
  QRS.B.ScaleError.cal          =       0.005000
QRS.A.ClockAngle                =       −173.700000
QRS.B.ClockAngle                =       6.300000
QRS.A.AlignError.enable         =       1
QRS.B.AlignError.enable         =       1
  QRS.A.AlignError.ClockAngle   =       0.000000
  QRS.B.AlignError.ClockAngle   =       0.000000
  QRS.A.AlignError.CantAngle    =       0.000000
  QRS.B.AlignError.CantAngle    =       0.000000
QRS.A.q_b2qrs =  0.000000000000  0.000000000000  0.744894056592  0.667182766905
QRS.B.q_b2qrs =  0.000000000000  0.000000000000 −0.667182766905  0.744894056592
QRS.A.SenseAxis.uvec_b  =       −0.99396096     −0.10973431      0.00000000
```

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```
QRS.B.SenseAxis.uvec_b  =        0.99396096      0.10973431      0.00000000
QRS.A.position_b        =        0.52491640      0.59430920      0.58765440
QRS.B.position_b        =        0.68762880     −0.38455600      0.58765440
QRS.A.FailTime          =       9999.0000
QRS.B.FailTime          =       9999.0000
QRS.A.Limits            =       −0.54105207      0.54105207
QRS.B.Limits            =       −0.54105207      0.54105207

NCS ELECTRONICS UNIT (NEU)
--------------------------
NCS.A.ControlSelect     =       3
NCS.B.ControlSelect     =       3
NCS.A.InputSelect       =       0
NCS.B.InputSelect       =       0
NCS.A.string            =       1
NCS.B.string            =       0
<< D E S I G N   A L G O R I T H M >>
  NCS.A.Filter.Num      =        1953.63940000   0.00000000      0.00000000
  NCS.B.Filter.Num      =        1953.63940000   0.00000000      0.00000000
  NCS.A.Filter.Den      =   1.0000   63.4577   2013.6386   1260.0754   773.2657
  NCS.B.Filter.Den      =   1.0000   63.4577   2013.6386   1260.0754   773.2657
  NCS.A.Coast.PreflightPeriod   =       1.4620
  NCS.B.Coast.PreflightPeriod   =       1.4620
  NCS.A.Coast.PreflightErrCov   =       0.096100
  NCS.B.Coast.PreflightErrCov   =       0.096100
  NCS.A.Coast.Threshold         =       −0.012217
  NCS.B.Coast.Threshold         =       −0.015708
  NCS.A.PwrFlt.Threshold        =        0.00872665      0.01745329
  NCS.B.PwrFlt.Threshold        =        0.00872665      0.01745329
  NCS.A.PwrFlt.Delay            =       15.000000
  NCS.B.PwrFlt.Delay            =       15.000000
  NCS.A.zcross                  =       −0.00261799      0.00000000
  NCS.B.zcross                  =       −0.00261799      0.00000000
  NCS.A.Coast.periodlimits      =        1.00000000      2.00000000
  NCS.B.Coast.periodlimits      =        1.00000000      2.00000000
  NCS.A.Coast.pulsewidth        =       0.0850
  NCS.B.Coast.pulsewidth        =       0.1100
  NCS.A.Coast.pulseoffset       =       −0.0200
  NCS.B.Coast.pulseoffset       =       −0.0200
  NCS.A.Coast.delay             =       15.0000
  NCS.B.Coast.delay             =       15.0000
  NCS.estimator.Q               =       0.000000
  NCS.estimator.R               =       0.002200
  NCS.estimator.P0              =       0.024000
  NCS.A.valvedelayestimate      =       0.0200
  NCS.B.valvedelayestimate      =       0.0200
```